Implications of Increased Climate Variability for Montana

Jesse Aber
Montana DNRC
Water Resources Division
June 12, 2008
AWSE Workshop – Big Sky

Montana Hydrology
Headwaters of the Continent

- Triple Divide Peak sends water to the Atlantic, Pacific, and Arctic Oceans
- Inflow of 15.5 MAF
- Outflow of 44 MAF
- The Origin of 28.5 MAF
- Headwaters Missouri and Columbia Rivers

Climate

- Defined often as average weather
- Weather – This week or month
- Climate – Over 30 years
- Climate anomalies – 1 to 20 years
- Climate change - Indefinite

Change is evident in Montana!

Glacier National Park, Grinnel Glacier

Photo: Fred Kiser, Glacier National Park archives

Photo: Karen Holzer, US Geological Survey

Glacier National Park, Boulder Glacier

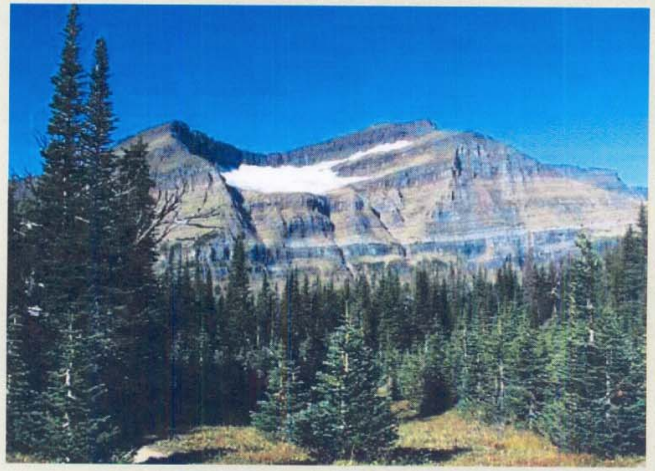
Photo: George Grant, Glacier National Park archives

Photo: Jerry DeSanto, National Park Service

Source: *BioScience*, Vol. 53 No. 2, Feb 2003

Climate Change – The Evidence

- Global average surface temperature has risen between 0.6°C and 0.7°C (1.2 F.) since the start of the Twentieth Century
- Rate of warming since 1976 has been three times faster than the century-scale trend.
- Up to 150 years ago, the ambient concentration of CO2 in the atmosphere varied between 180 to 280 parts per million by volume (ppmv). Today the concentration is about 380 ppmv and climbing.



Montana Climate Change Action Plan

Final Report of the Governor's Climate Change Advisory Committee

November 2007

Montana's GHG Emissions

- Montana's GHG emissions from all sources accounted for 0.6% of total US GHG emissions in 2005.
- Montana's rate of GHG emissions per capita is nearly double the national average

Why?

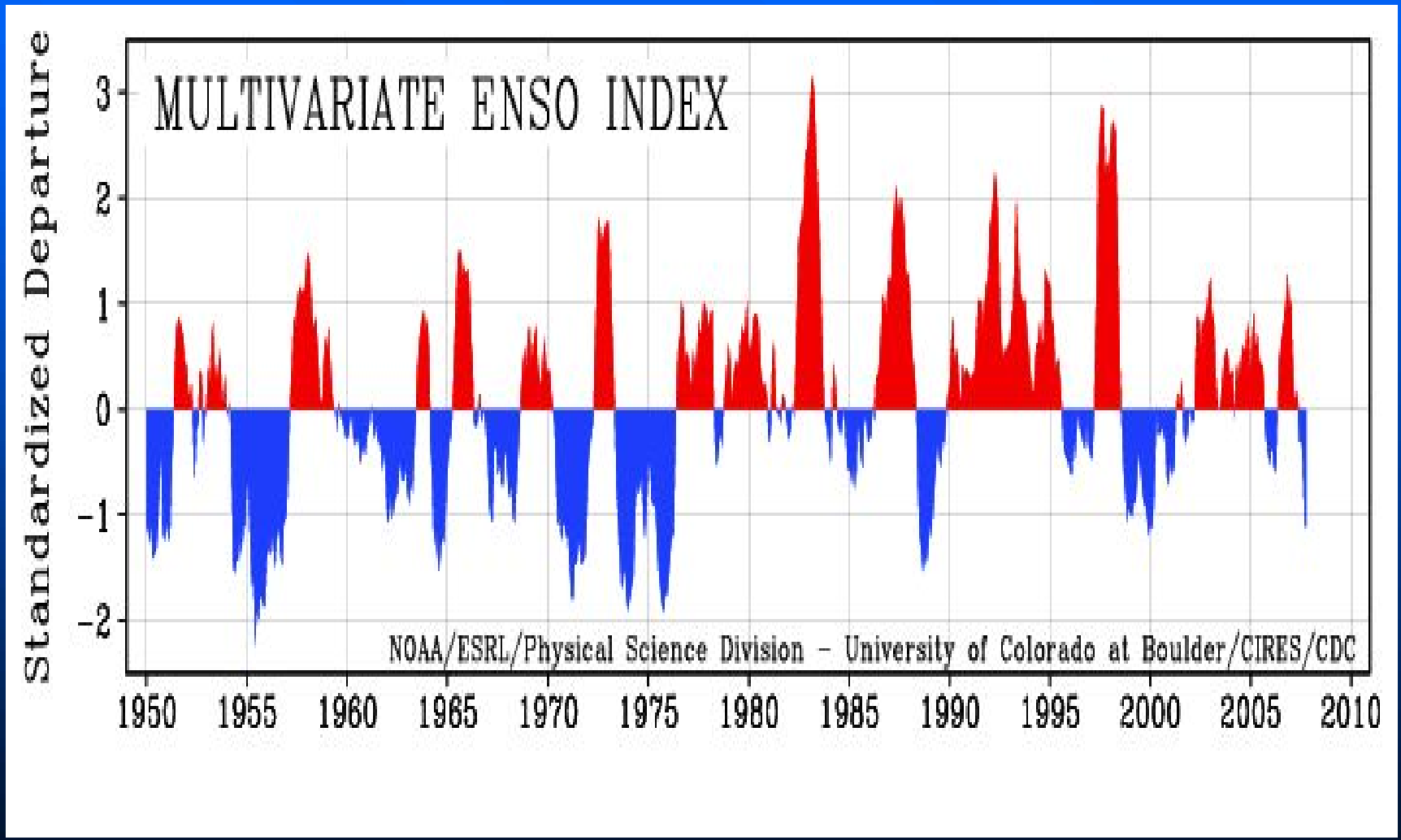
- Our large fossil fuel production industry, substantial agriculture industry, large transportation distances, cooler climate and low population base!

2/28/08 - Ice sheet the size of Connecticut collapses in Antarctica.

What can Montana expect?

- Temperature change
- Higher latitudes – Greater increases
- Warmth extending later in Fall
- Earlier melt of mountain snowpack
- Warmth earlier & longer in Spring
- Extreme Summer heat waves
- Wildfires – Earlier, hotter, more numerous
- Higher daily highs and lows
- Precipitation – Higher intensity; shorter duration events – Amount same or increase

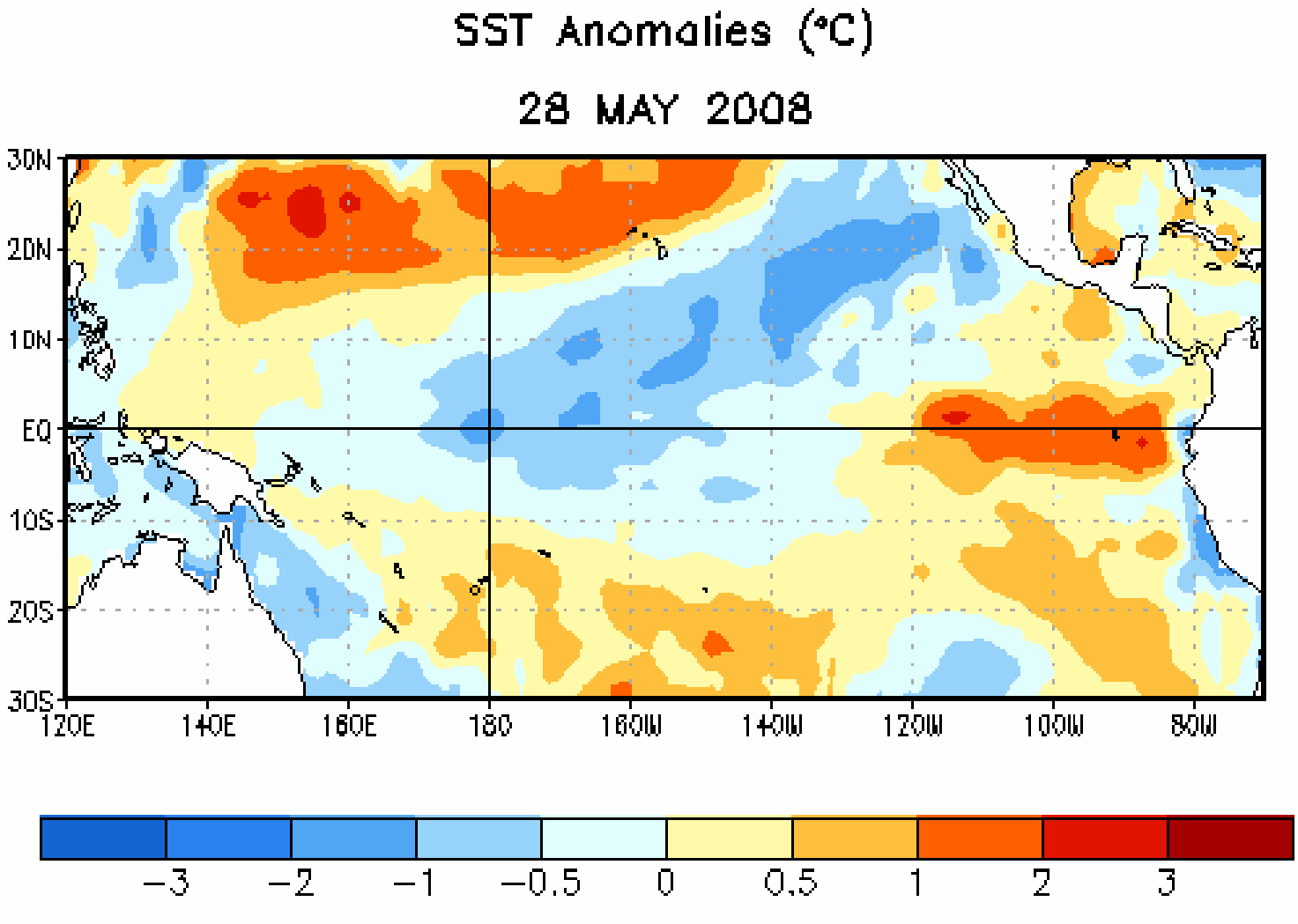
Climate Anomalies
El Nino / La Nina – Warm & Cold



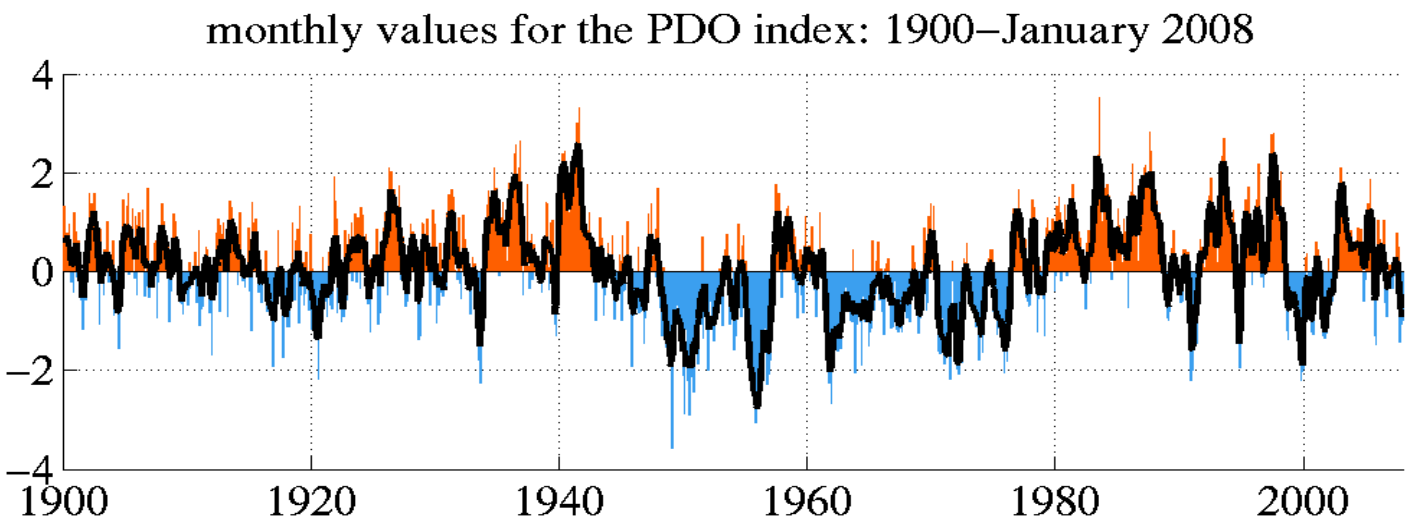
Richard Seager – Paleo-climatologist

- *Medieval mega-droughts too may have been caused by the tropical Pacific seesaw getting stuck in something like a perpetual La Niña.*
- *The future, though, won't be governed by that kind of natural fluctuation alone.* ***Thanks to our emissions of greenhouse gases, it will be subject as well to a global one-way trend toward higher temperatures.***

La Nina weakening to neutral



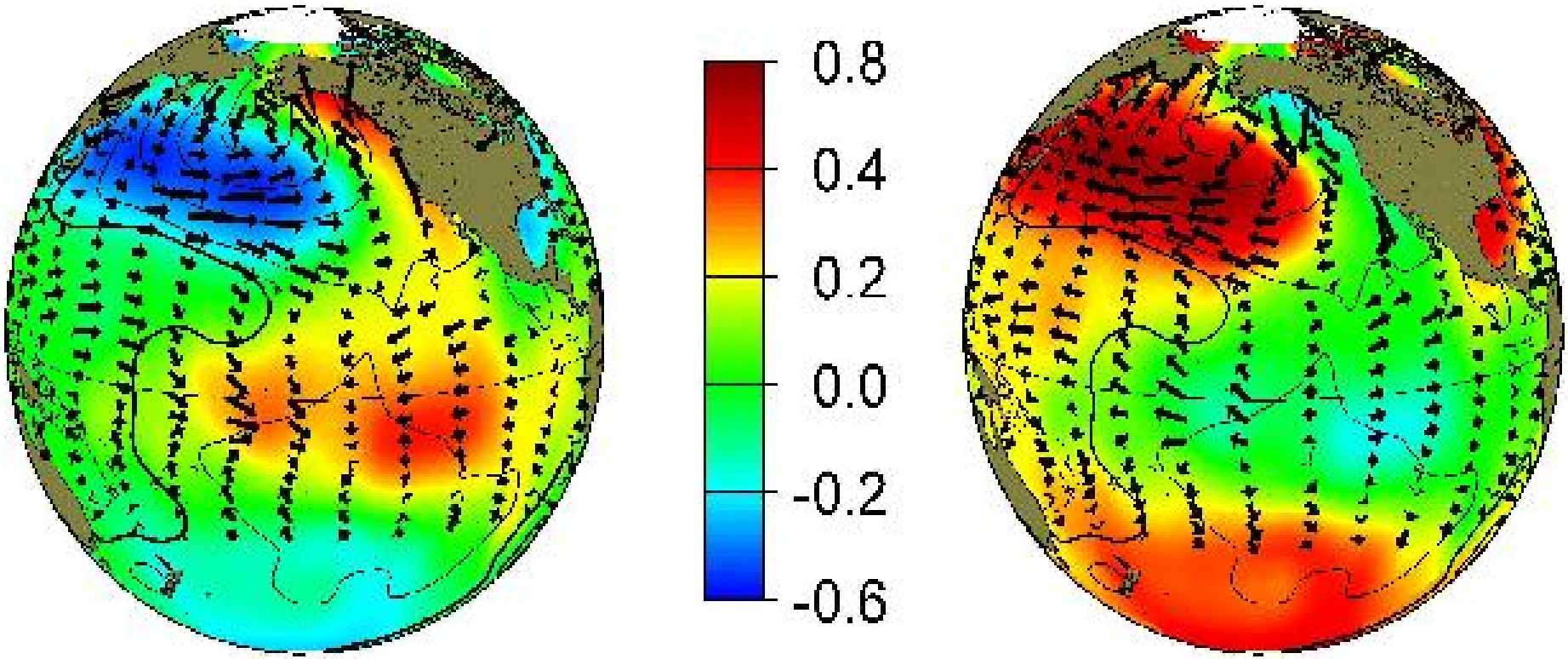
Pacific Decadal Oscillation - PDO



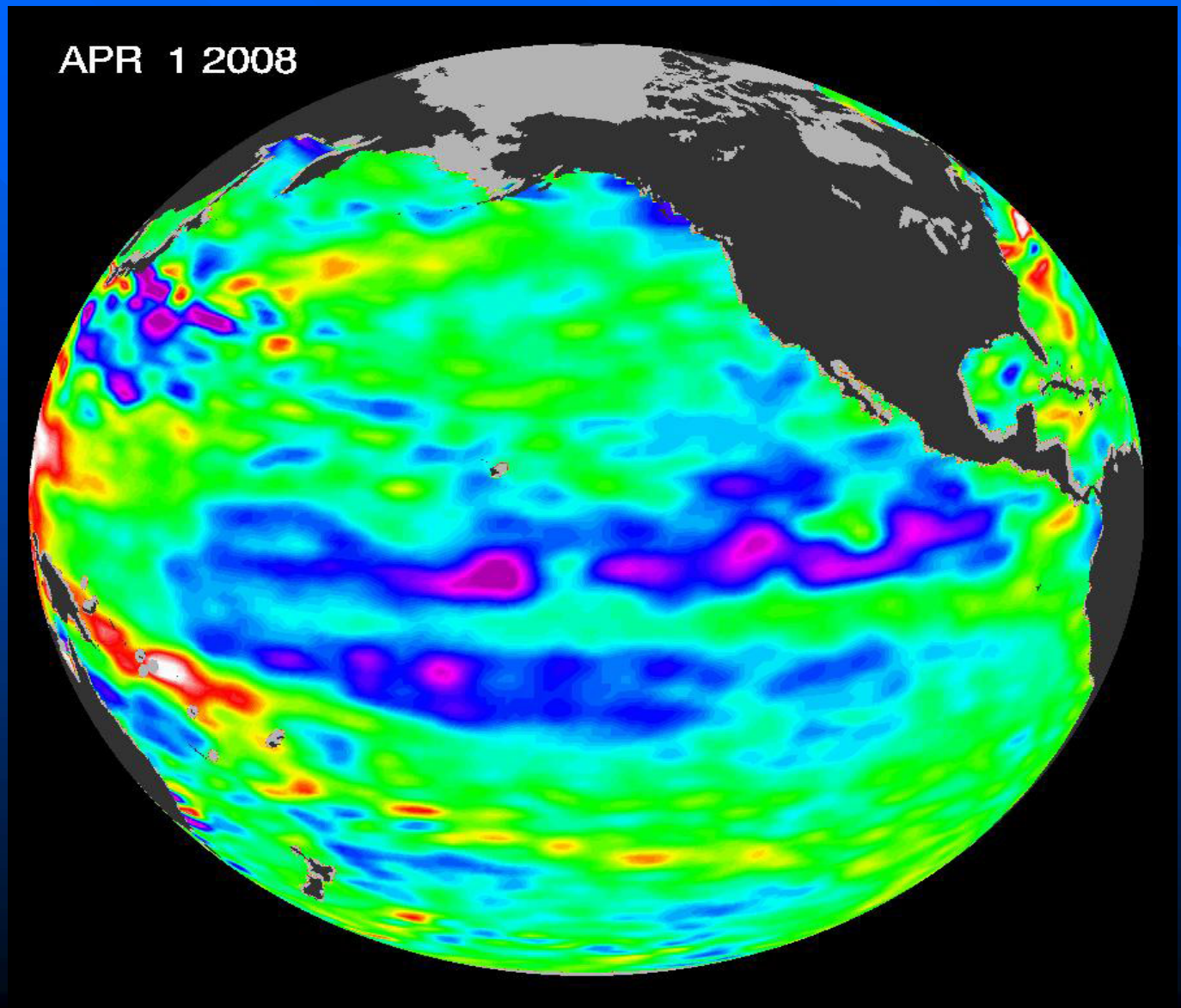
NASA Release April 21, 2008

- La Niña is occurring within the context of a larger climate event, the early stages of a cool phase of the basin-wide Pacific Decadal Oscillation (PDO).
- “This multi-year Pacific Decadal Oscillation 'cool' trend can intensify La Niña or diminish El Niño impacts around the Pacific basin."

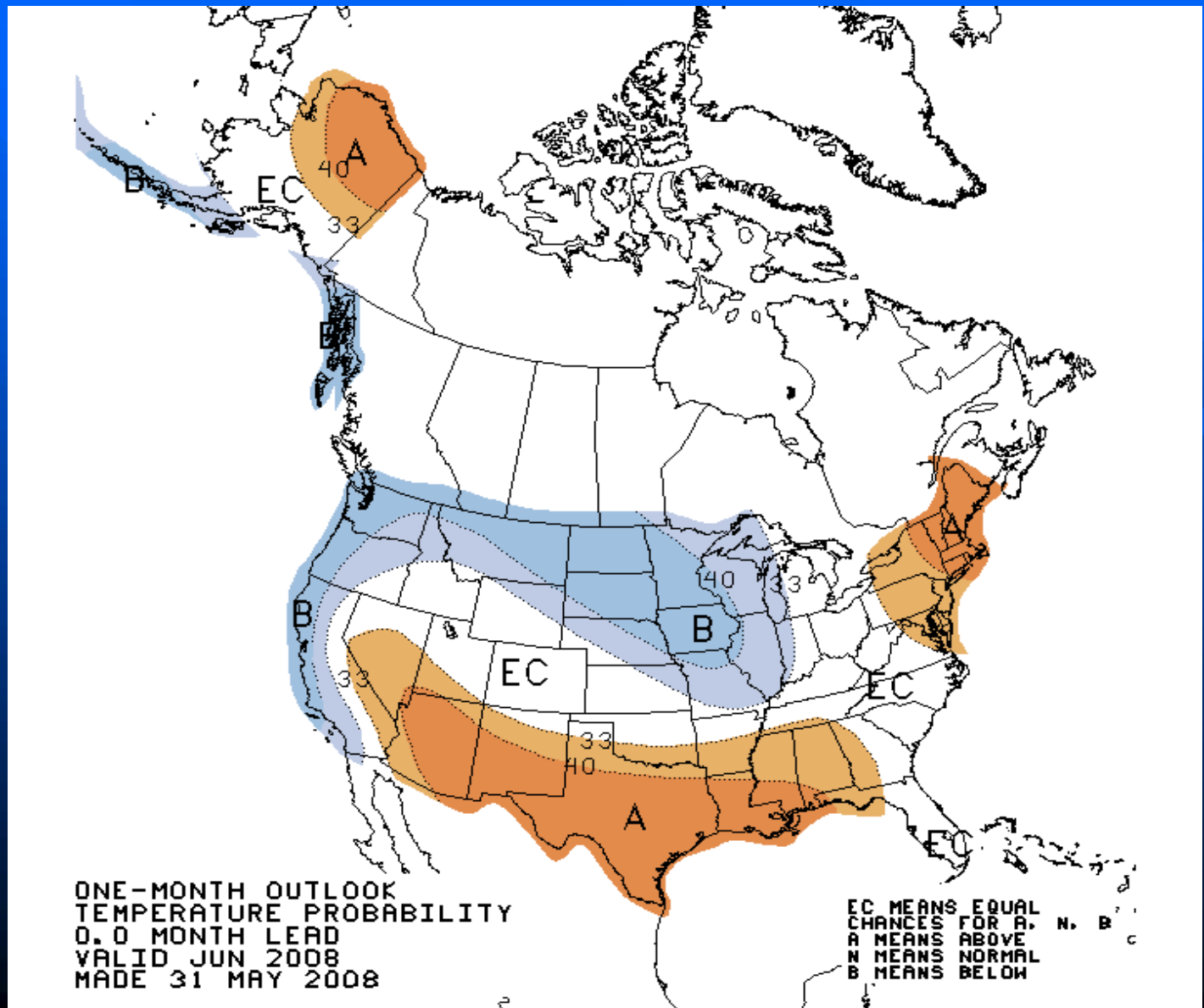
Warm Phase – PDO – Cool Phase



Cool Phases – ENSO & PDO



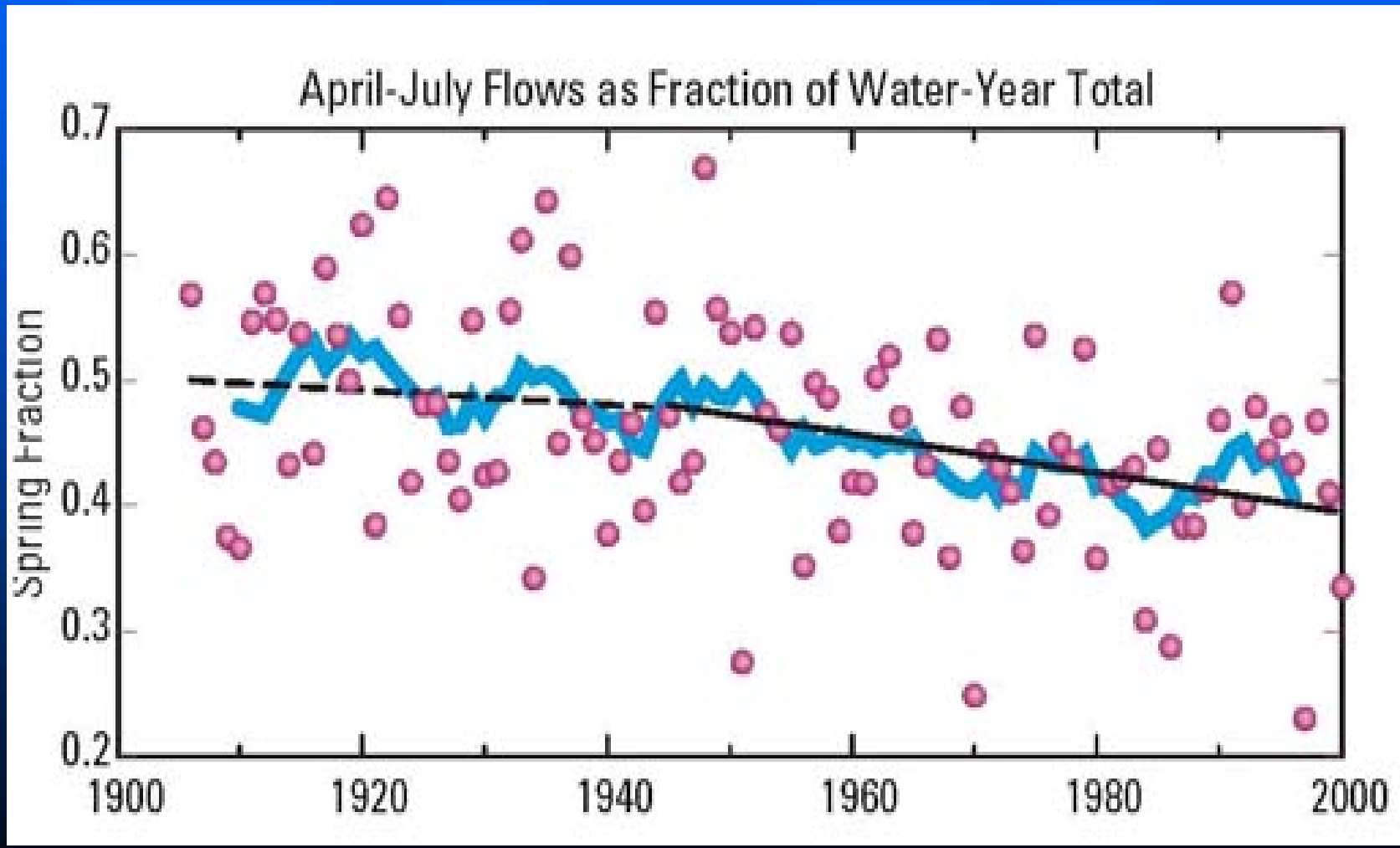
CPC Outlook for June – PDO?



Temperature Change Consequences

- Smaller mountain snowpacks
- Fall streamflow increases
- Increased chances of rain on snow events
- Earlier periods of Spring high streamflow
- Low Summer flows arrive earlier
- Dramatic increases in Summer ET (Evapotranspiration)

USGS – Streamflow trends in Western U.S. Fact Sheet 2005-3018



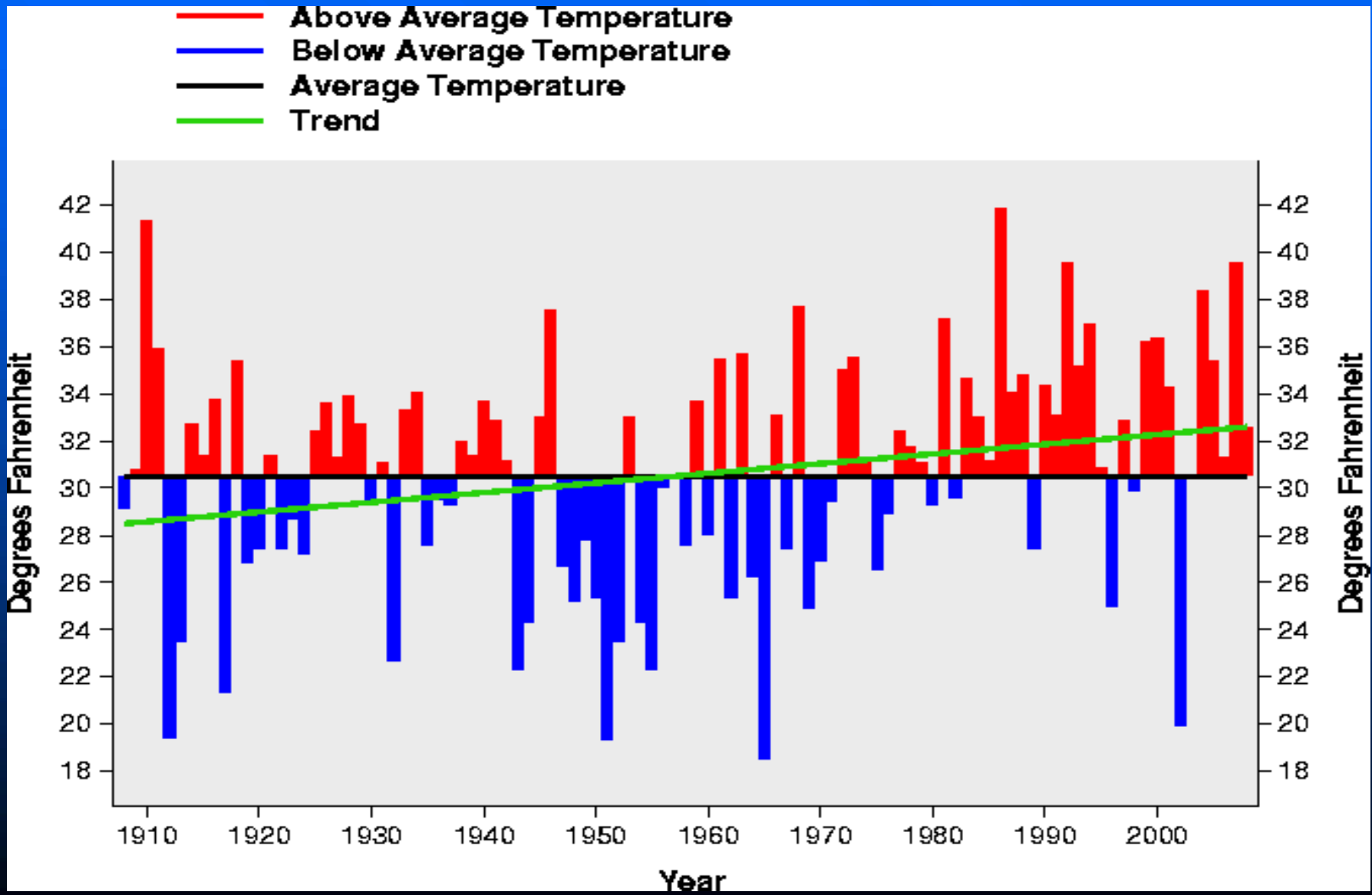
USGS Conclusion

- The observed streamflow timing and winter-spring warming trends are consistent with current projections of how greenhouse effects may influence western climates and hydrology; thus streamflow timing and trends may be attributed, in part, to global warming.

Temperature Change Implications

- Smaller snowpacks less resistant to warmth
- Fall flows change reservoir storage plans
- Winter rains cause flooding & damage
- Earlier spring flows challenge water users
- Earlier Summer low flow woes
- High summer temps increase plant demand

Montana March 1908 - 2008 Trend = 0.41 degF / Decade – 4.1 degF



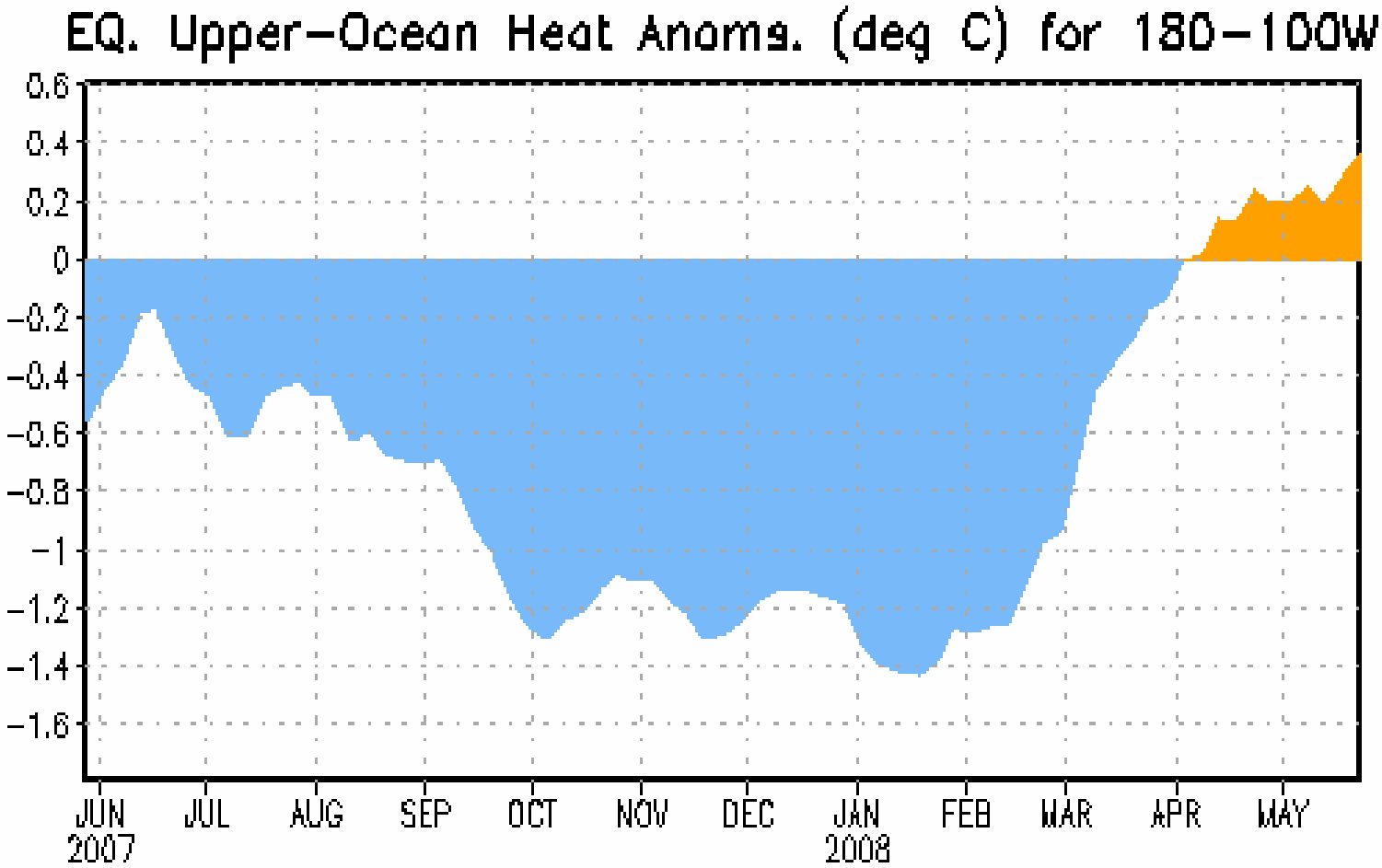
Water Year 2007
Preview of the Future?

- La Nina arrives
- Rains, not snow continue into November
- Damage occurs from Fall flooding
- Snowpack water content only about 75%
- Early Spring protracted warmth takes 30% off snow water content of snowpack
- Water use season starts with 40 percent of average snow water runoff.

2007 (cont.)

- Generous spring rainfall did not compensate for traditional spring / summer snowmelt.
- Excess Fall & Spring precip stored
- Record heat arrives early in July.
- Streamflow plummets.
- Water temps climb.
- Fishing restrictions imposed – 30+ streams!
- Winter crops fare well; Spring crops do not.

La Nina Arrives – Fall 2007



Rain, not snow into Fall
Many Glacier – Nov. 7, 2006

Temperatures finally cooled….

Damage occurs from Fall flooding Going to the Sun Highway

Spring snowpack woes
Warm spell #1 – Lost 25% SWE

SNOTEL DATA AS OF May 14, 2007

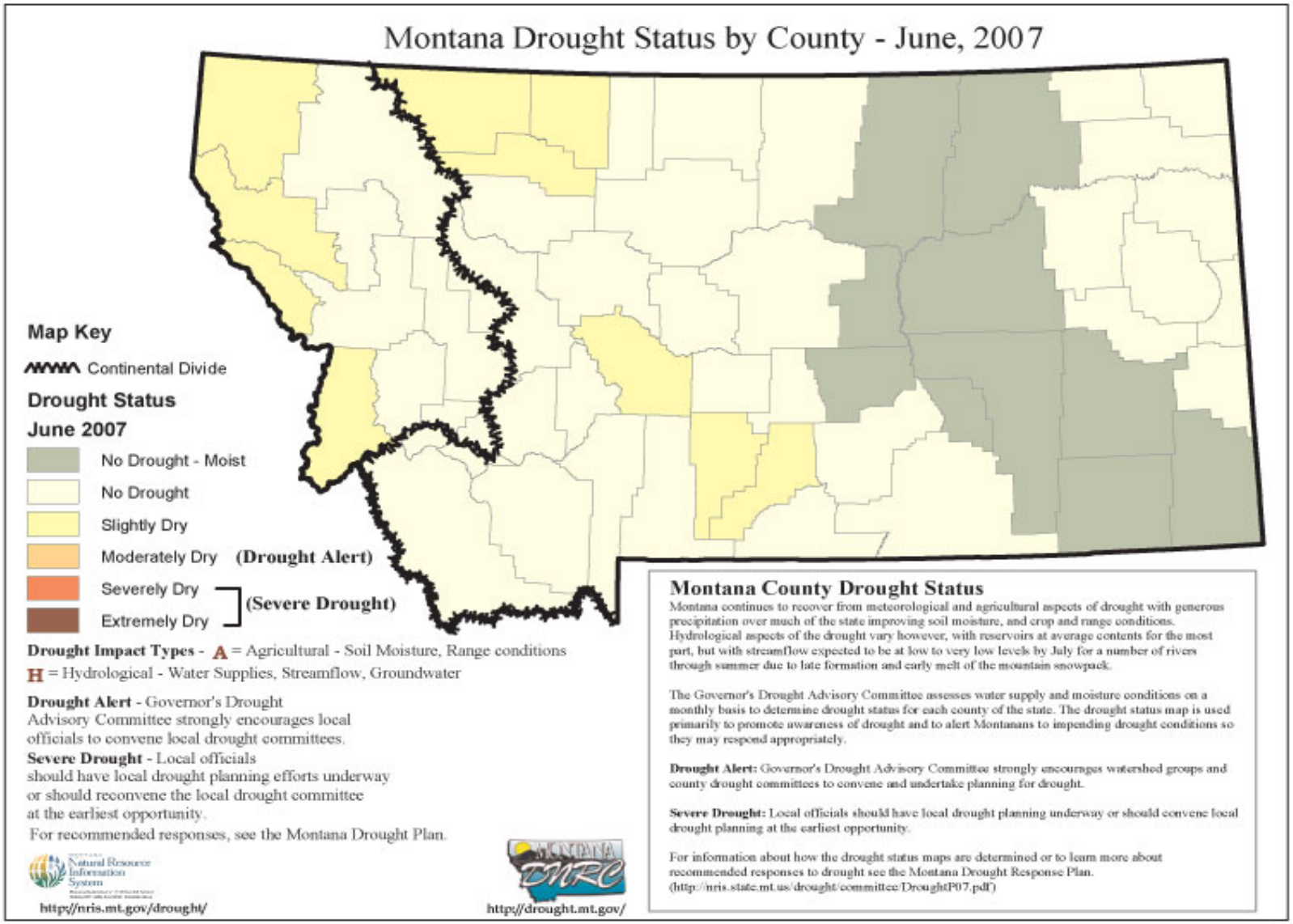
Date	Basin	This Year % of ave.	This Week versus Last Week	Last Year % of ave.	This Year as % of Last Year
5/14/2007	Kootenai	69%	-15%	104%	66%
	Flathead	75%	-8%	99%	76%
	Upper Clark Fork	59%	-20%	87%	68%
	Bitterroot	47%	-14%	91%	52%
	Lower Clark Fork	45%	-19%	91%	49%
	Jefferson	44%	-19%	80%	55%
	Madison	39%	-23%	97%	40%
	Gallatin	36%	-25%	83%	43%
	Missouri Headwaters	39%	-22%	86%	45%
	Headwaters Mainstem	30%	-27%	74%	41%
	Smith,Judith,Musselshell	33%	-31%	83%	40%
	Sun,Teton,Marias	46%	-14%	75%	61%
	Missouri Mainstem	38%	-22%	76%	50%
	St. Mary	81%	-3%	98%	82%
	Upper Yellowstone	41%	-18%	75%	55%
	Lower Yellowstone	51%	-25%	49%	104%
	State-wide	48%	-19%	84%	57%

Warm spell #2 – Lost 20% SWE

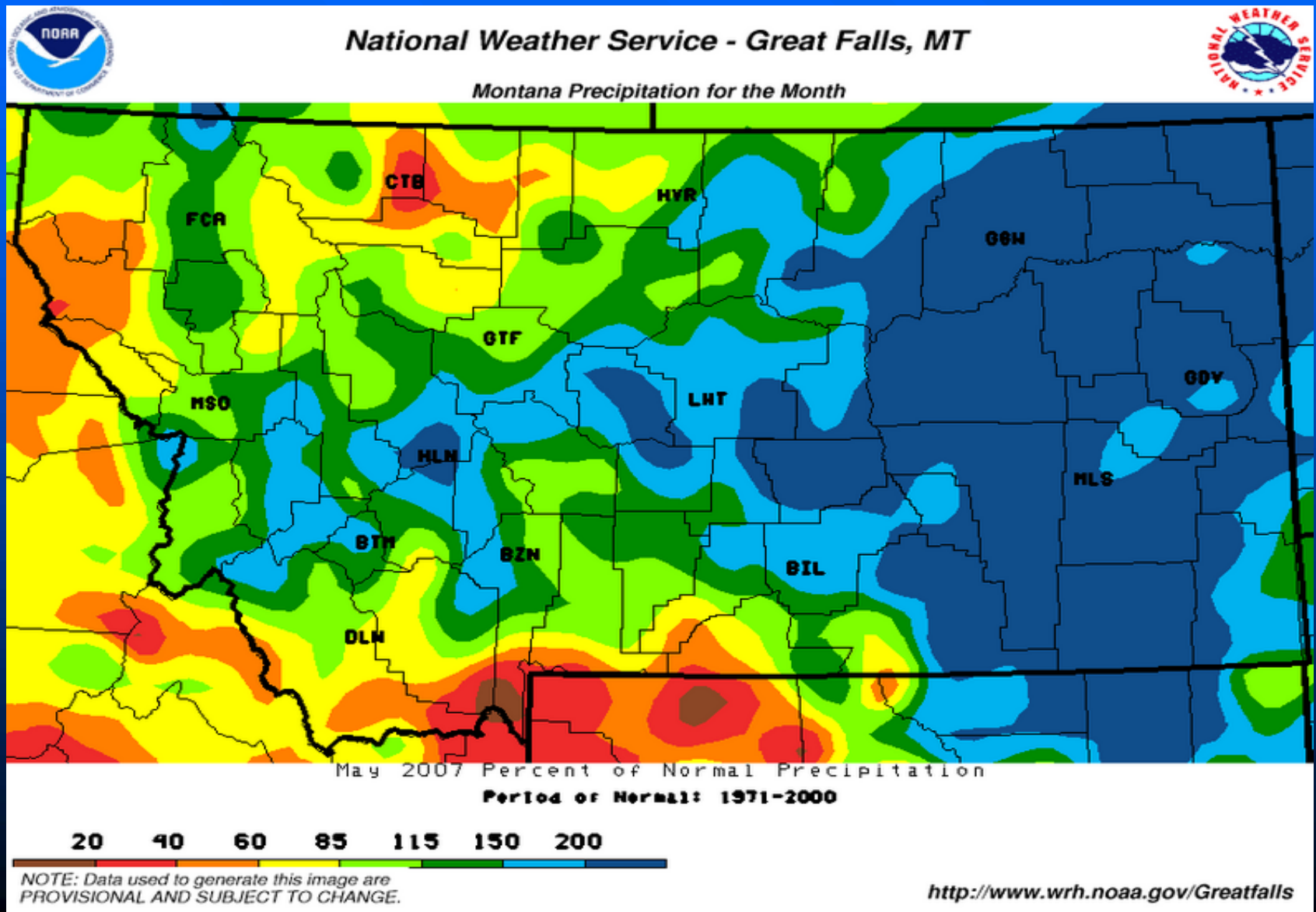
SNOTEL DATA AS OF May 21, 2007

Date	Basin	This Year % of ave.	This Week versus Last Week	Last Year % of ave.	This Year as % of Last Year
5/21/2007	Kootenai	59%	-10%	90%	66%
	Flathead	70%	-5%	87%	80%
	Upper Clark Fork	42%	-17%	64%	66%
	Bitterroot	23%	-24%	76%	30%
	Lower Clark Fork	30%	-15%	67%	45%
	Jefferson	27%	-17%	61%	44%
	Madison	17%	-22%	78%	22%
	Gallatin	21%	-15%	65%	32%
	Missouri Headwaters	23%	-16%	67%	34%
	Headwaters Mainstem	10%	-20%	50%	20%
	Smith,Judith,Musselshell	12%	-21%	59%	20%
	Sun,Teton,Marias	30%	-16%	49%	61%
	Missouri Mainstem	20%	-18%	52%	38%
	St. Mary	76%	-4%	93%	82%
	Upper Yellowstone	27%	-14%	58%	47%
	Lower Yellowstone	29%	-22%	30%	97%
	State-wide	32%	-16%	65%	49%

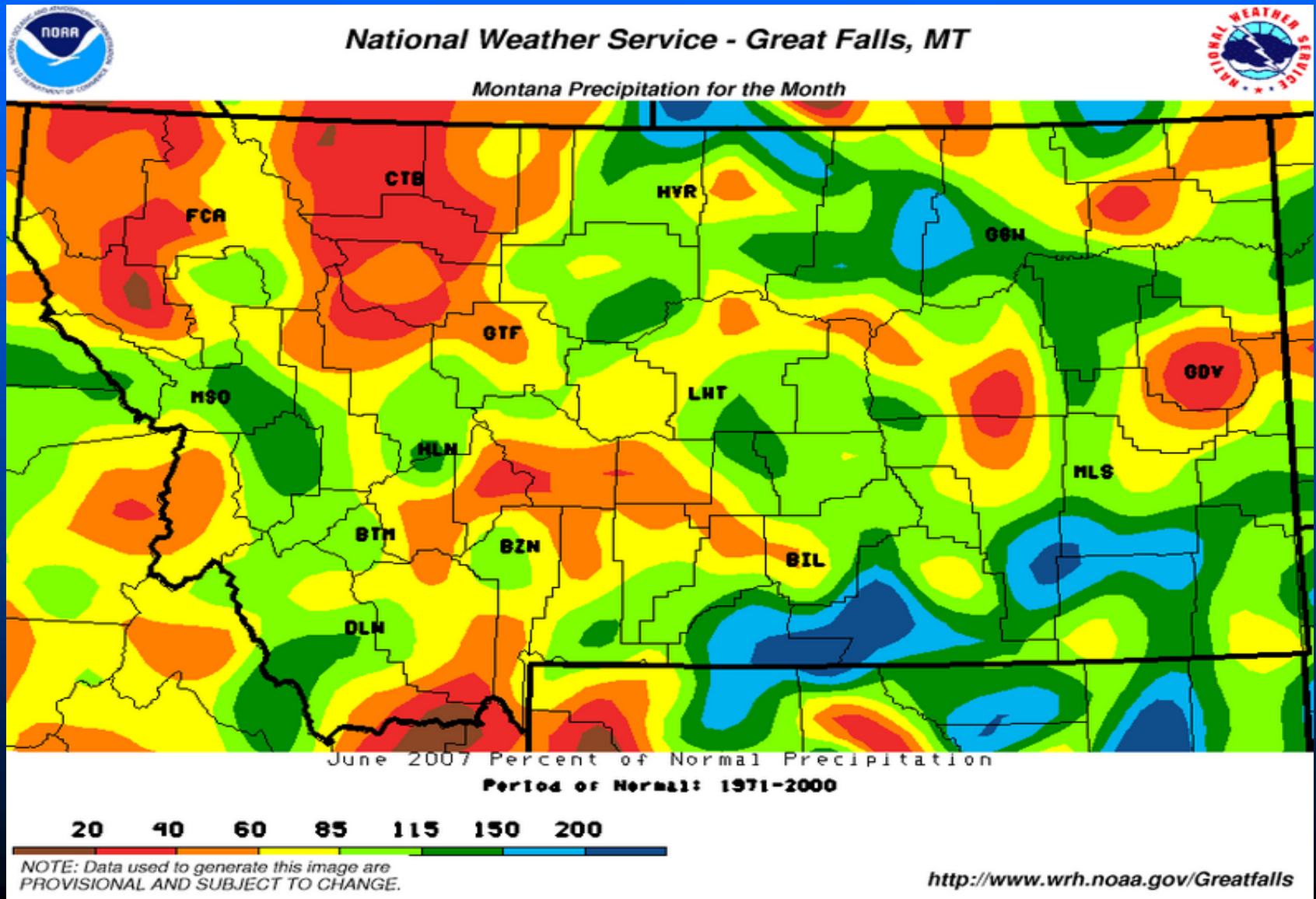
Would the rains save us?



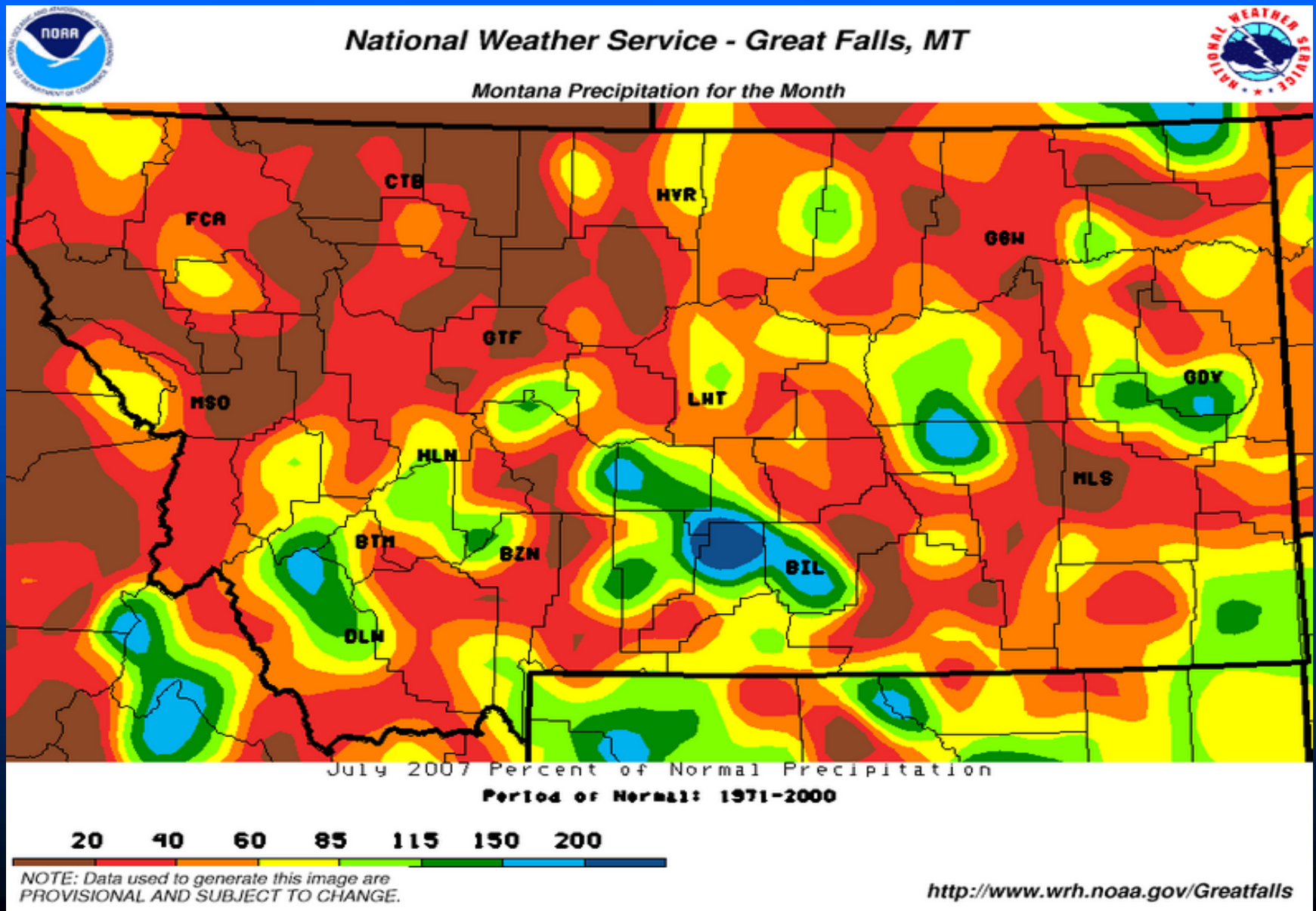
May was very good to Montana



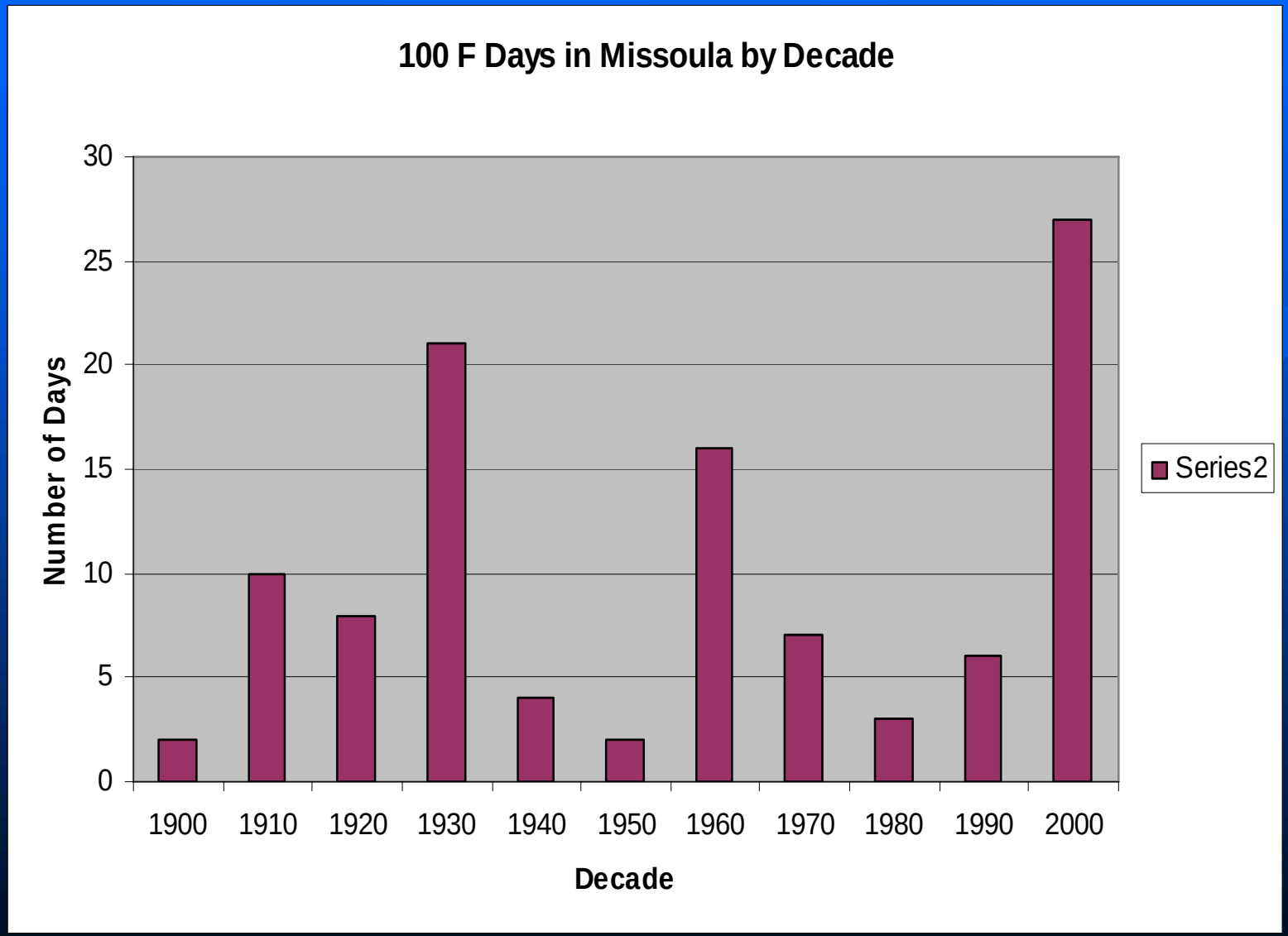
June moisture was spotty



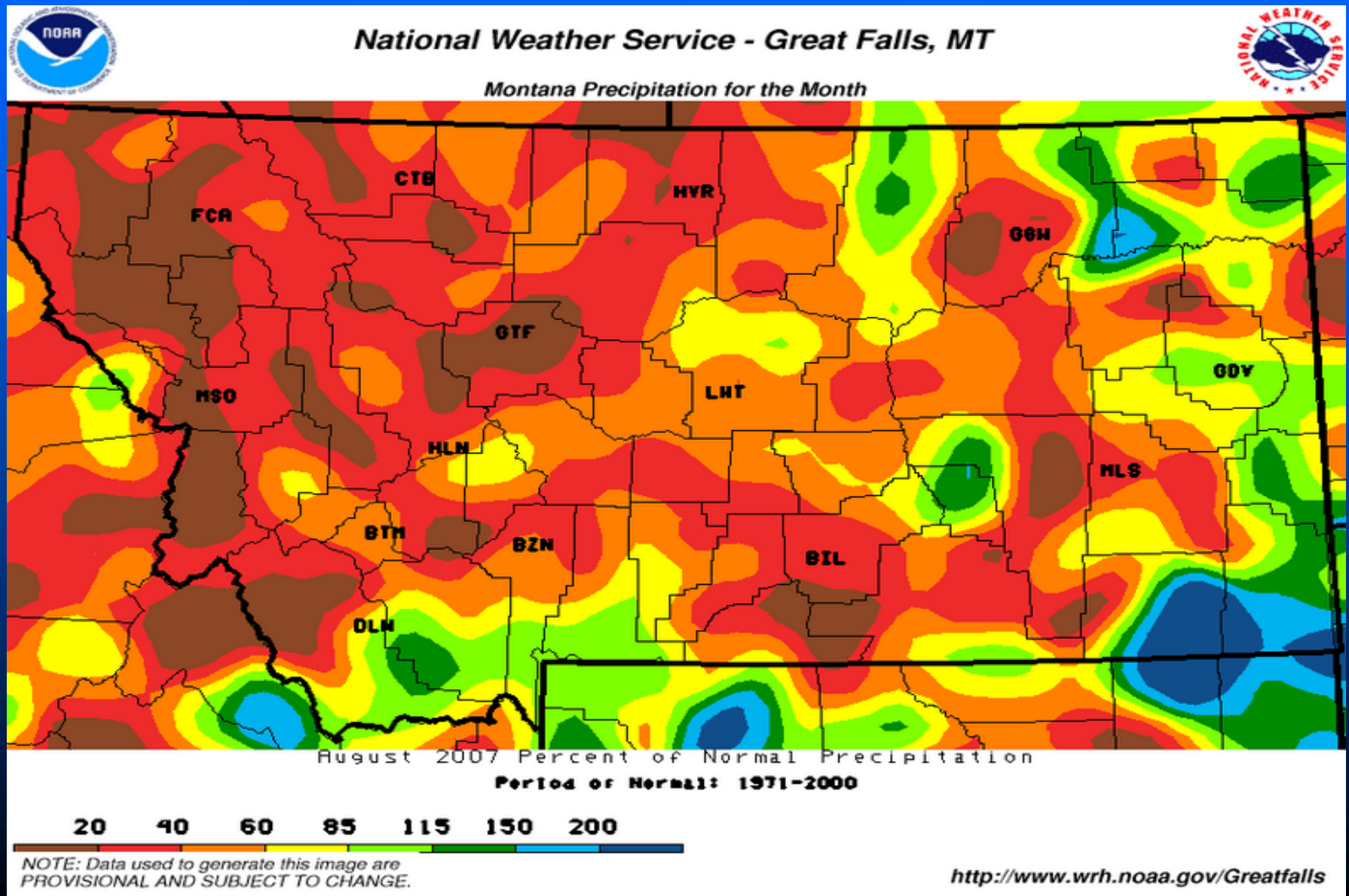
July was hot & dry!



Missoula – The Garden City



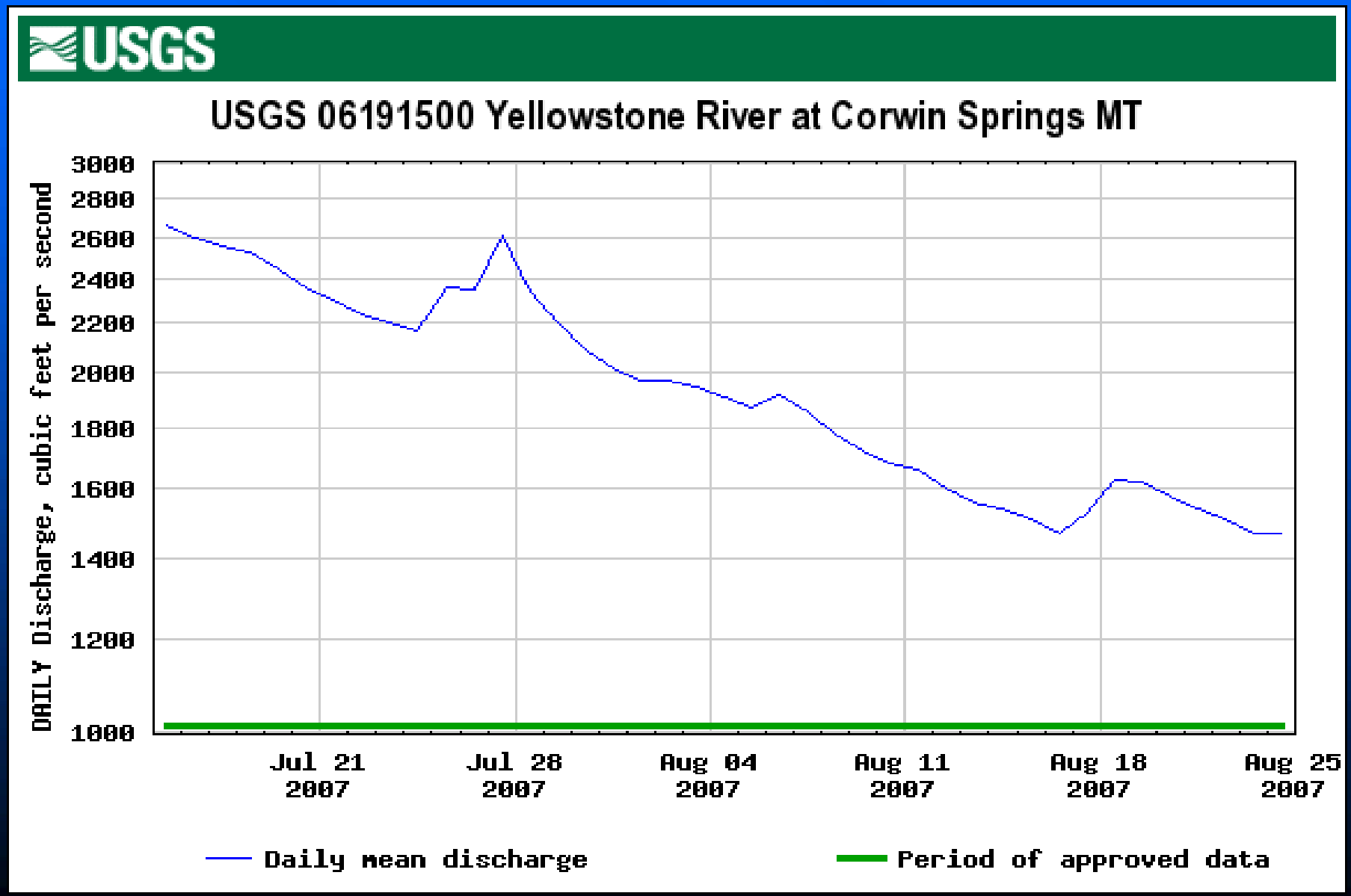
August – Dry again!



New Missoula Records - 2007

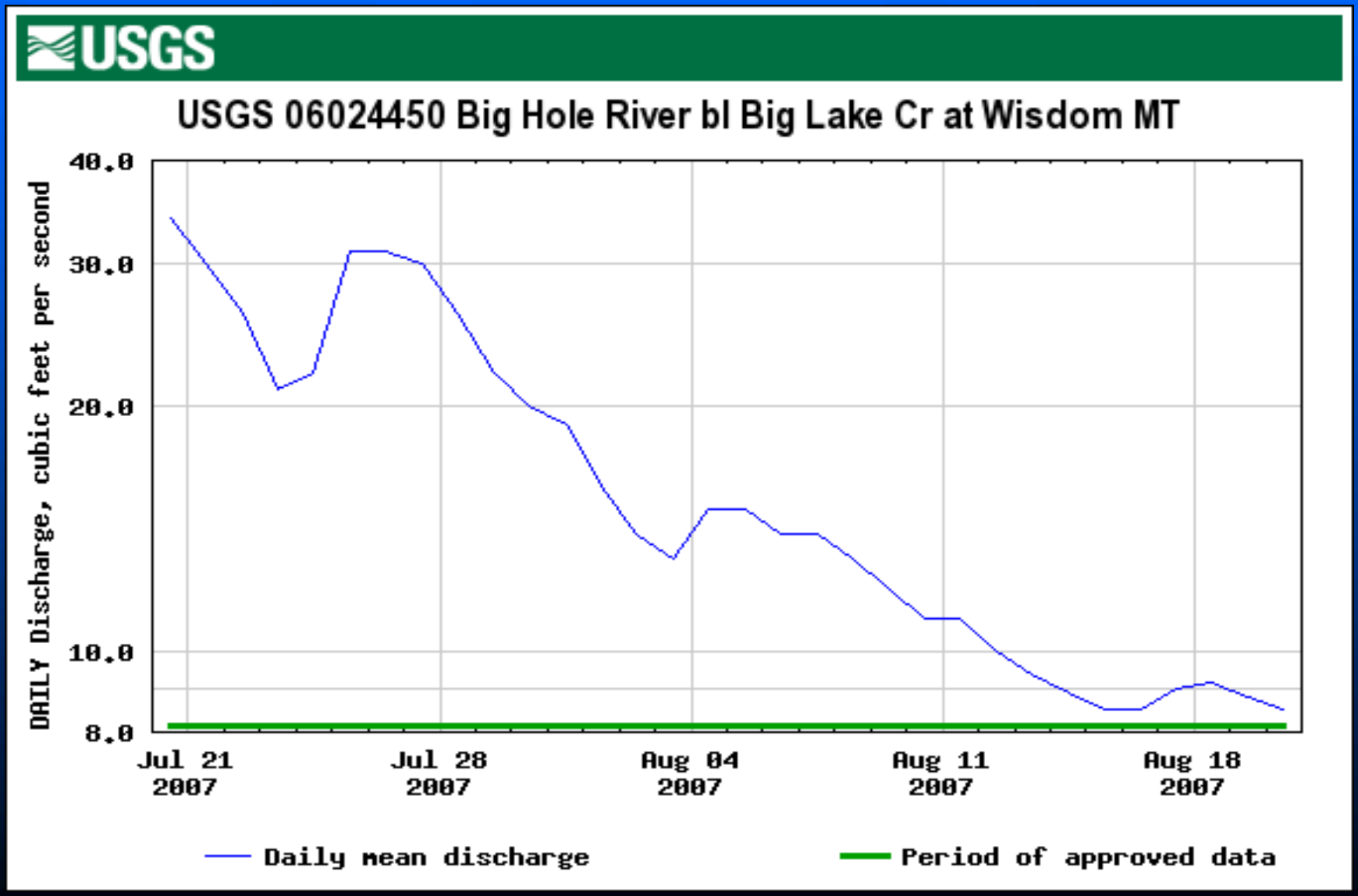
- *Hottest Temperature Ever – 107degrees F*
- *Warmest Night Ever – 71degrees F*
- *Average Temp – 78.1 – 11.2 F above average*
- *Most number of days at or over 100 F – 11*
- *Old record – 6 days in 1936*
- *Record number of 95 F and above days – 24*
- *Old record – 20 in 1960 & 2003*
- *Average is 4 days over 95 F*
- *Record number of days over 90 F- 53*
- *Record was 41days in 1940*
- *Average is 18 days over 90 F*
- *Most number of nights 60F and above – 19*

Earlier Summer low flow woes

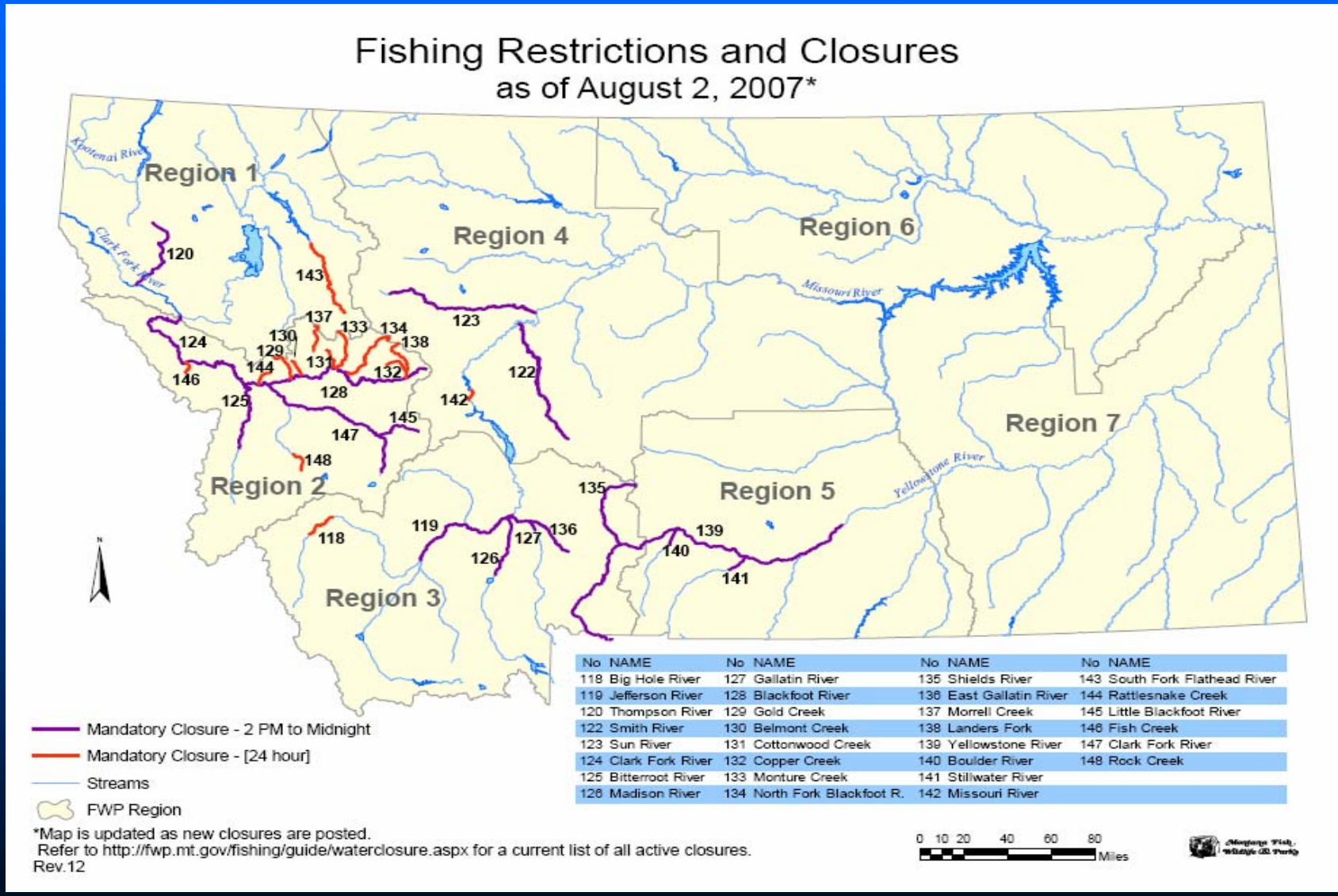


Jefferson River – August low flows & warm water temperatures

Big Hole – Grayling & trout concern



FWP Angling restrictions



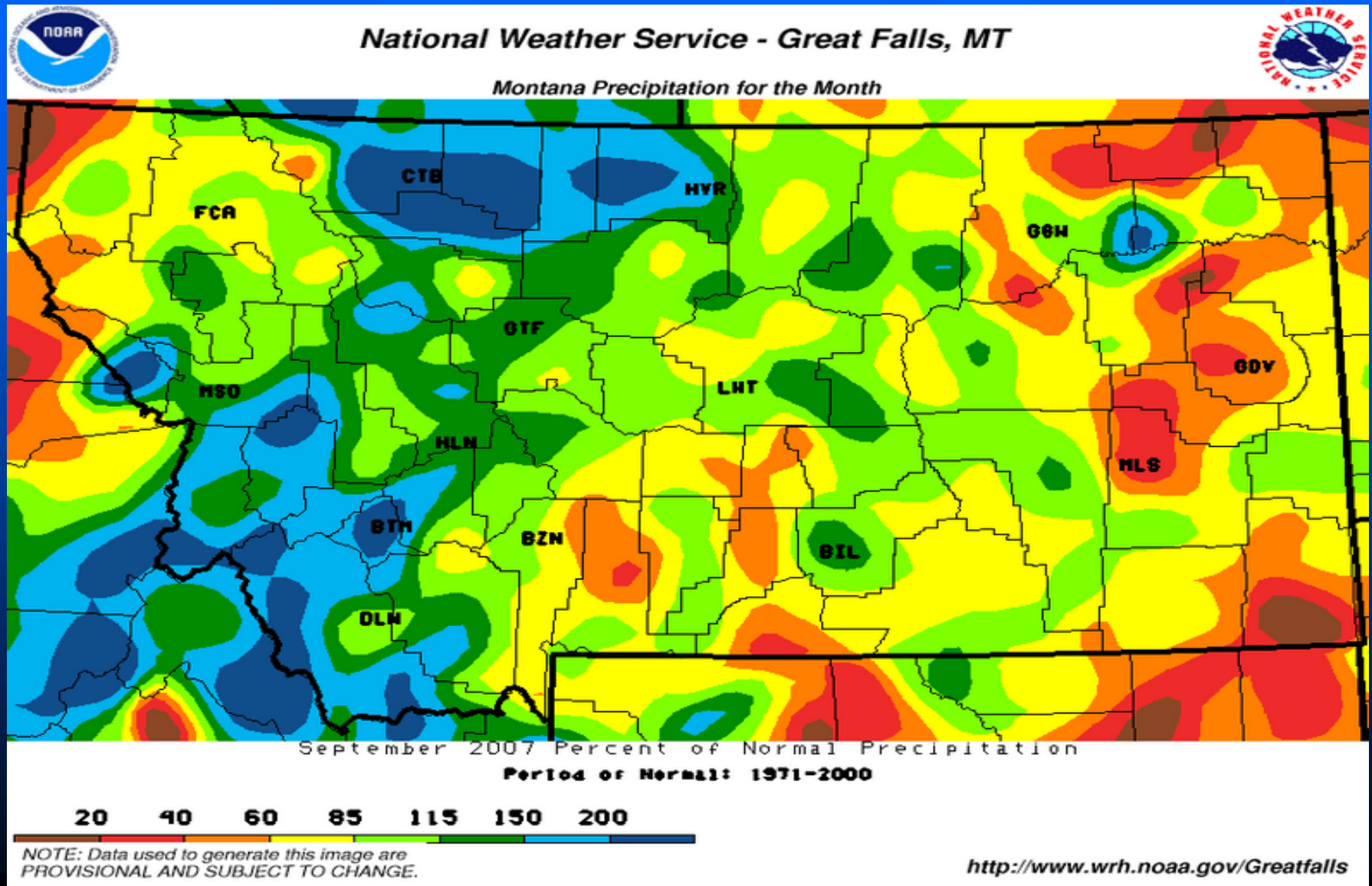
No	NAME	No	NAME	No	NAME	No	NAME
118	Big Hole River	127	Gallatin River	135	Shields River	143	South Fork Flathead River
119	Jefferson River	128	Blackfoot River	136	East Gallatin River	144	Rattlesnake Creek
120	Thompson River	129	Gold Creek	137	Morrell Creek	145	Little Blackfoot River
122	Smith River	130	Belmont Creek	138	Landers Fork	146	Fish Creek
123	Sun River	131	Cottonwood Creek	139	Yellowstone River	147	Clark Fork River
124	Clark Fork River	132	Copper Creek	140	Boulder River	148	Rock Creek
125	Bitterroot River	133	Monture Creek	141	Stillwater River		
126	Madison River	134	North Fork Blackfoot R.	142	Missouri River		

*Map is updated as new closures are posted.
Refer to http://fwp.mt.gov/fishing/guide/waterclosure.aspx for a current list of all active closures.
Rev.12

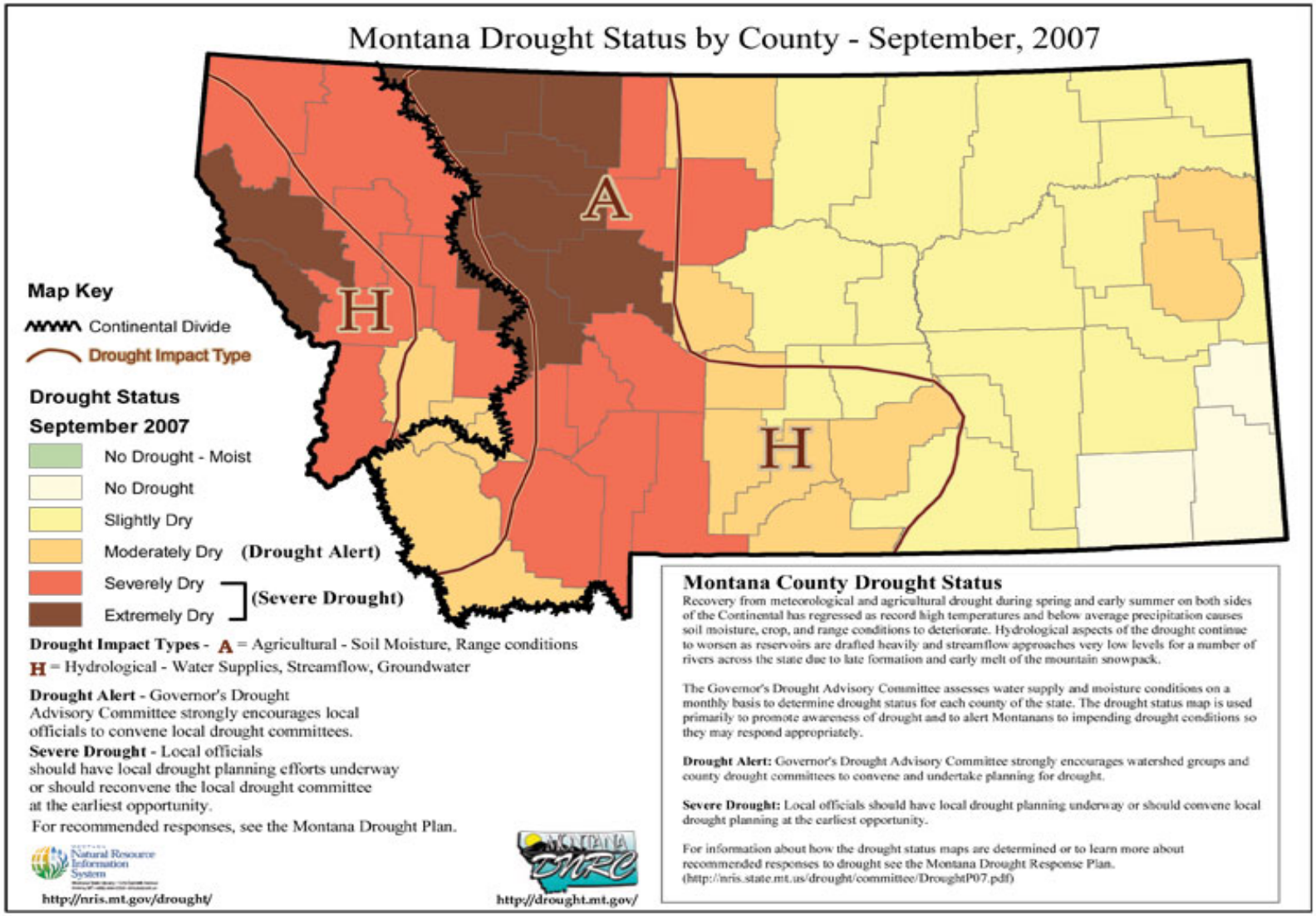
Big Business for Montana

Fire suppression 2007 - $50M

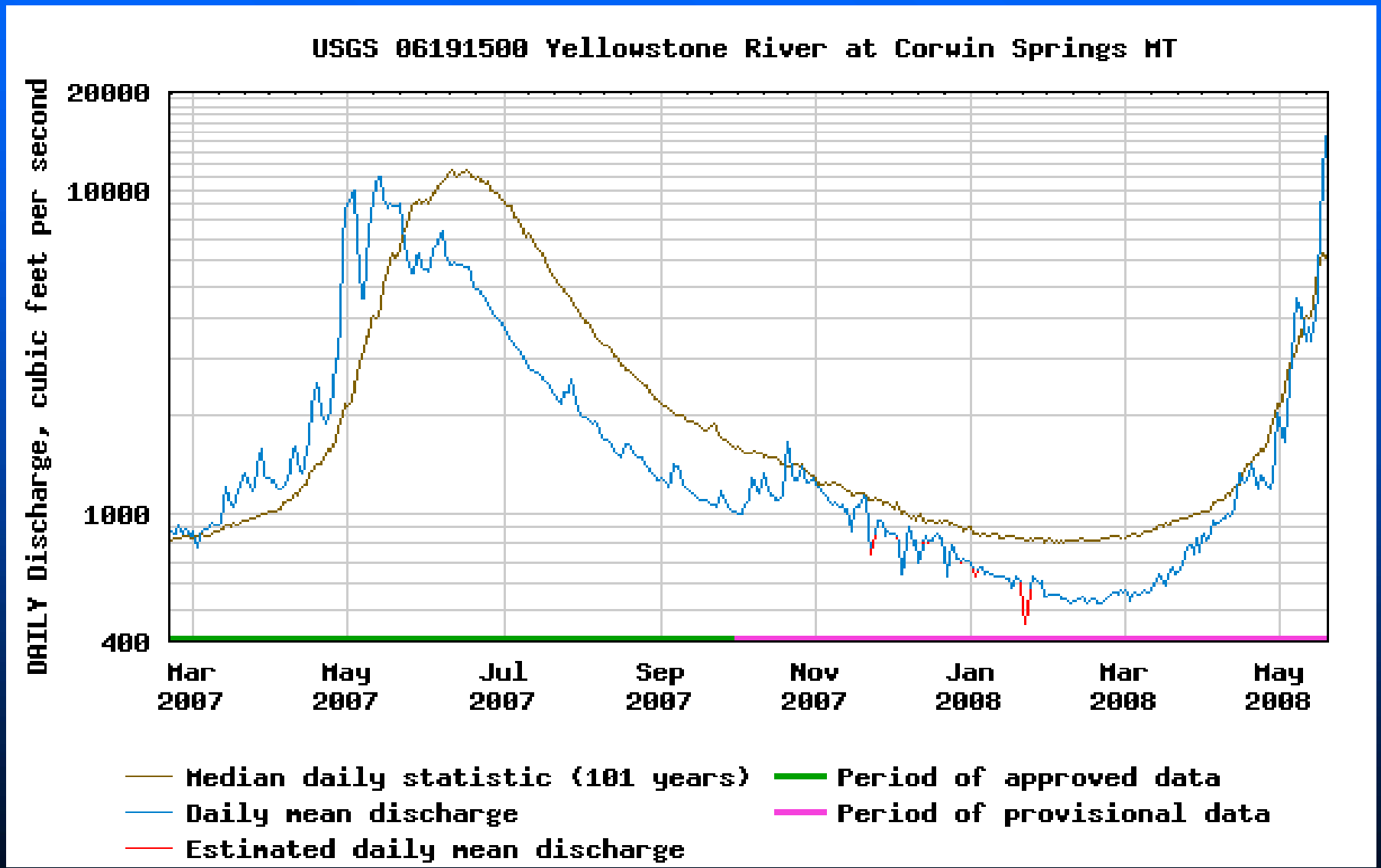
September spelled relief!



The record heat was too much.



Yellowstone River – 2007-2008



Response – Trust Climate Forecasts

A POLICY FORUM: IMPROVING RESPONSES TO CLIMATE PREDICTIONS

developed by the

ATMOSPHERIC POLICY PROGRAM
AMERICAN METEOROLOGICAL SOCIETY

in collaboration with

Columbia University

Study Series Underwriters

ITT Industries
Engineered for life

Raytheon

Study Donor
Space Systems Loral

Washington, D.C.
April 23-24, 2003

Responses to Increased Variability

- Risk management – water supply & climate
- Water conservation – Irrigation scheduling
- Water right adjudication / enforcement
- Emphasis on demand reduction
- Consider supply side solutions
- Education & Outreach
- NIDIS – Reconstruction of scenarios with guidance for affected sectors
- Greenhouse gas emission reduction

Responses (cont.)

- Forestry – Fuel reduction / snow harvest
- Weather Modification – Monitor progress
- Water banking / GW Storage
- Agriculture – Drought resistant crops; no till farming; snow harvest; new crops
- Storage – Capacity increase during rehabs
- Trans-boundary water right issues
- Irrigation conveyance efficiencies
- Domestic exemptions / conservation

Big Hole River control structure

Big Hole – New gauge for drought plan implementation - 2008

Liberty County – May 2, 2002

Blackfoot River – August 2007

Smith River – August 2001

The End

Questions

&

Answers